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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

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NUCLEAR SCIENCE

Factors Leading to the Termination of the Antares Laser Research Program

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Resources, Community, and
Economic Development Division

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June 13, 1990

The Honorable Mike Synar
Chairman, Environment, Energy,
and Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

Your May 3, 1989, letter asked us to review certain aspects concerning the termination of the Antares Laser Research Program[1] at the Department of Energy's (DOE) Los Alamos National Laboratory (Los Alamos), in Los Alamos, New Mexico. As agreed with your office, this report provides information on the (1) reasons for terminating the Antares program, (2) adequacy of the technical review given the Antares program before its termination, and (3) preliminary results of the National Academy of Sciences' (Academy) current review of DOE's defense Inertial Fusion Program, as it pertains to a laser technology similar to that used in the Antares program.[2]

Results in Brief

The Antares Laser Research Program was terminated by Los Alamos at the end of fiscal year 1985 because of a technical problem. Los Alamos found that long-wavelength lasers generate electrons that preheat the target containing the fuel for the fusion reaction, effectively preventing fusion. DOE and Los Alamos believed the problem would have required developing an impractically large and expensive laser system for effective use of the technology Antares represented. According to Los Alamos, its efforts to overcome the technical problem were unsuccessful.

Before it terminated the program, Los Alamos conducted two technical evaluations and concluded that the Antares technology was not a good candidate for achieving fusion. Both evaluations were reviewed—one by an independent scientific panel and the other by the Academy. Both reviews supported Los Alamos' conclusion. Accordingly, we believe that the program was given adequate technical review before its termination.

[1]Antares was a long-wavelength carbon dioxide laser, developed as part of DOE's Inertial Fusion Program, to evaluate whether such laser technology could achieve fusion. Fusion is a nuclear reaction in which nuclei combine to form more massive nuclei with the simultaneous release of energy.

[2]The Antares program and the proposed hydrogen fluoride laser program reviewed by the National Academy of Sciences panel are similar in that both are based on long-wavelength laser technology.

In response to a congressional mandate, in late 1989 the Academy again reviewed DOE's Inertial Fusion Program, including a laser technology similar to that used in Antares. The Academy's interim report, issued in January 1990, again concluded that long-wavelength laser technology is not a viable candidate for fusion and recommended that DOE not pursue the technology. The Academy's final report is due in September 1990.

Background

The Antares laser was built in 1983 as part of DOE's Inertial Fusion Program—a program directed toward demonstrating the feasibility of achieving fusion by using intense laser or particle beams to heat and compress targets containing small masses of thermonuclear fuel. Inertial confinement fusion attempts to mimic, on a miniature scale, the physics of a thermonuclear explosion. The ability to create fusion in the laboratory, according to the Academy, could eliminate the need for certain underground nuclear tests.

After its 1983 construction, Antares competed with two other fusion programs to help DOE determine (1) the feasibility of heating and compressing small masses of thermonuclear fuel (conditions necessary for fusion) and (2) the technology (i.e., the type of laser or particle beam) with the greatest potential for achieving fusion. One program was at the Lawrence Livermore National Laboratory in Livermore, California, and the other was at Sandia National Laboratory in Albuquerque, New Mexico. DOE's goal was to determine which of the technologies being developed by the DOE laboratories should be the basis for the future direction of fusion research.

Antares was designed to evaluate long-wavelength laser technology for inertial confinement fusion. At the time the Antares program was initiated, Los Alamos believed that long-wavelength carbon dioxide lasers were a promising candidate technology for driving a fusion reaction. Long-wavelength carbon dioxide lasers offered several technical advantages such as laser energy efficiency, the ability to focus the laser beam, and relatively low estimated cost. Antares was built in 1983 and operated through its termination at the end of fiscal year 1985 at a total cost of about $80 million.

The National Defense Authorization Act for fiscal year 1989, and the conference report that accompanied the fiscal year 1989 Energy and Water Development Appropriation Act, directed that DOE form a panel to conduct a review of its Inertial Fusion Program. DOE contracted with the Academy to conduct that review. The Academy's review included an

assessment of the most promising technologies and their potential contributions under a prohibition of underground nuclear testing (the preliminary results of that review are discussed later in this letter).

Antares Was Terminated Because of a Technical Problem

After obtaining data from Antares experiments and underground nuclear tests, Los Alamos reported that long-wavelength lasers generate electrons that preheat the target, raise the temperature of the fuel prematurely, and effectively prevent fusion. Los Alamos concluded that its attempts to ameliorate the undesired effects of the electrons were unsuccessful. The Director of DOE's Office of Inertial Fusion testified in May 1985, before the Subcommittee on Energy Research and Development, Senate Committee on Energy and Natural Resources, that, compared to short-wavelength lasers, the long-wavelength approach would create fusion only with impractically large and expensive systems. Los Alamos terminated the Antares program at the end of fiscal year 1985.

Los Alamos had planned additional tests of the Antares laser that were not conducted due to the termination of the program at the end of fiscal year 1985. Los Alamos officials told us that they did conduct experiments with Antares in the mode of operation that the canceled tests were intended to evaluate. They added that their decision not to conduct additional Antares experiments was based on a review of the results of these experiments, the results of other experiments, and the theoretical data that the tests were intended to evaluate. Los Alamos concluded that even if further tests were successful, the improvements in efficiency would have been only a fraction of that necessary to make Antares a viable candidate for achieving fusion.

Independently Reviewed Technical Evaluations Found Antares to Be Infeasible

Los Alamos conducted two internal evaluations of carbon dioxide laser technology; both were independently reviewed. The first evaluation, conducted in March 1983, was intended to ascertain whether the energy of a carbon dioxide laser can be efficiently used to achieve fusion. Los Alamos concluded that carbon dioxide lasers would not meet fusion needs and have an inherent problem in that they generate unwanted electrons. Furthermore, Los Alamos reported that the generation of unwanted electrons would increase at the energy levels necessary to achieve fusion. In addition, Los Alamos reported that its attempts to use these electrons to achieve fusion had failed.

Los Alamos subsequently tasked an independent scientific panel to review its March 1983 report. Specifically, Los Alamos asked the review

panel to provide ". . . a fresh perspective on the adequacy of the scientific data base from which we reached our decisions, insights into areas of relevant theory or experiments overlooked, and suggestions as to the experiments that should have the highest priority." The review panel consisted of representatives from Princeton University, the Universities of Maryland and Colorado, the Mission Research Corporation, R&D Associates, and the Lawrence Livermore National Laboratory.

In its May 1983 response, the review panel concurred with the findings from Los Alamos' March 1983 evaluation and also concluded that Los Alamos' methodology was appropriate and thorough. The panel also offered suggestions on how to use the unwanted electrons generated by the Antares laser to assist in creating conditions conducive to fusion and suggested further experiments using Antares.

After incorporating the review panel's suggestions, including conducting certain priority Antares experiments, Los Alamos conducted a second technical evaluation in March 1984. The purpose of the second evaluation was to evaluate carbon dioxide lasers for inertial fusion. The evaluation confirmed the findings in the previous internal evaluation, namely, that carbon dioxide lasers generate unwanted electrons. Los Alamos reported that attempts to ameliorate the effects of these electrons did not produce obvious improvements and concluded that carbon dioxide lasers would not meet fusion needs.

In May 1985, Los Alamos briefed the Academy on its evaluation of carbon dioxide lasers for fusion as part of a congressionally authorized and presidentially directed review of DOE's Inertial Fusion Program. The Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1985 directed the President to establish a group to conduct a technical review of the Inertial Fusion Program. The President's Science Advisor asked the Academy to carry out the review mandated by the act. Specifically, the Academy was asked to review the accomplishments, management, goals, and anticipated program contributions.

The Academy, in a March 1986 report, concurred with Los Alamos' conclusions, stating that the large numbers of unwanted, or "hot," electrons generated by long-wavelength carbon dioxide lasers preheat the target too much to permit the efficient heating and compression of the fuel necessary to achieve fusion. The Academy also noted that although Los Alamos made a valiant effort to use these unwanted electrons, "it was

ultimately accepted that a successful design would be difficult if not impossible."

Preliminary Results of the National Academy of Sciences' Recent Review of DOE's Inertial Fusion Program

In November 1989, the Academy again reviewed DOE's Inertial Fusion Program, including long-wavelength laser technology similar to that represented by Antares as part of another review of DOE's Inertial Fusion Program. This review was mandated by DOE's fiscal year 1989 authorization act and the conference report that accompanied its fiscal year 1989 appropriation act. The Academy recommended against further research in this area.

The Academy's January 1990 interim report stated, in reference to a long-wavelength laser technology similar to Antares, that "We share the prevailing view of the ICF [inertial confinement fusion] community that a retreat to longer wavelengths makes little sense. . . ." Accordingly, the report recommended against research in this area. However, the executive director of the Academy's review panel told us that the panel will again review the available technical information related to long-wavelength laser technology during the preparation of its final report. The Academy's final report is due in September 1990.

Conclusions

Los Alamos terminated the Antares laser program because it encountered a technical problem that it believed made the Antares technology a poor candidate for achieving fusion. The two technical evaluations conducted by Los Alamos were reviewed by independent scientific panels that supported the decision to terminate Antares. This information leads us to conclude that the program was given adequate technical review prior to its termination. Further, the conclusions regarding long-wavelength laser technology reached by the Academy in its January 1990 interim report also support the decision to terminate Antares.

Scope and Methodology

In performing our review, we examined various classified and unclassified studies, reports, correspondence, and congressional testimony related to the termination of the Antares program. We examined Los Alamos' two technical evaluations related to Antares as well as the National Academy of Sciences' report on DOE's Inertial Fusion Program, dated March 1986, and the preliminary report based on its most recent review, dated January 1990. We interviewed program officials at DOE

headquarters and at the Los Alamos National Laboratory. We also interviewed the staff director for the Academy's 1989 review of DOE's Inertial Fusion Program.

We conducted our review in accordance with generally accepted government auditing standards. However, as requested, we did not seek formal agency comments on this report. We did discuss the contents of this report with DOE headquarters and Los Alamos staff, who generally agreed with the facts presented in this report. We have incorporated their comments where appropriate.

We conducted our review between June 1989 and February 1990. As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies to the Secretary of Energy; the Director, Office of Management and Budget; and other interested parties. If you have any questions or concerns, please contact me at (202) 275-1441. Major contributors to this report are listed in appendix I.

Sincerely yours,

Victor S. Rezendes
Director, Energy Issues

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Appendix I

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